MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS TECHNOLOGY TRANSFER (STTR)
STTR 07 Proposal Submission Instructions

INTRODUCTION

The MDA STTR program is implemented, administrated and managed by the MDA Office of Small and Disadvantaged Business Utilization (SADBU). If you have any questions regarding the administration of the MDA STTR program please call 703-553-3414. Additional information on the MDA STTR Program can be found on the MDA STTR home page at http://www.winmda.com . Information regarding the MDA mission and programs can be found at http://www.mda.mil.

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (22 Jan 2007 through 19 Feb 2007), contact the Topic Authors listed under each topic on the http://www.dodsbir.net website through 19 Feb 2007. After 19 Feb 2007, technical questions regarding topics will only be accepted via the online SITIS Interactive Topic System on the http://www.dodsbir.net/ web site.

As funding is limited, MDA will select and fund only those proposals considered to be superior in overall technical quality and most critical. MDA may fund more than one proposal in a specific topic area if the technical quality of the proposal is deemed superior, or it may fund no proposals in a topic area.

PHASE I GUIDELINES

MDA intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost not exceeding $100,000.

A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from the MDA Programs and are directly linked to their core research and development requirements.

Please ensure your e-mail address listed in your proposal is current and accurate. MDA cannot be responsible for notification to companies that change their mailing address, their e-mail address, or company official after proposal submission.

Phase I Proposal Submission

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. Only UNCLASSIFIED proposals will be entertained. MDA accepts Phase I proposals not exceeding $100,000. The technical period of performance for the Phase I should be 6 months. MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

If you plan to employ NON-U.S. Citizens in the performance of a MDA STTR contract, please identify these individuals in your proposal as specified in Section 3.5.b (7) of the program solicitation.

It is mandatory that the ENTIRE technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD website at: http://www.dodsbir.net/submission. If you have any questions or problems with the electronic proposal submission contact the DoD Helpdesk at 1-866-724-7457.

This COMPLETE electronic proposal submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site http://www.dodsbir.net/submission will lead you through

the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal submission must be submitted via the submission web site on or before the 6 a.m. 21 Mar 2007 deadline. Proposal submissions received after the closing date and time will not be processed.

PHASE II GUIDELINES

This solicitation solicits Phase I Proposals. MDA makes no commitments to any offeror for the invitation of a Phase II Proposal. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. Only those successful Phase I efforts that are **invited** to submit a Phase II proposal will be eligible to submit a Phase II proposal.

Invitations to submit a Phase II proposal will be made by the MDA STTR Program Manager (PM) or one of MDA's executing agents for STTR. Phase II proposals may be submitted for an amount normally not to exceed $750,000. Companies may, however, identify requirements with justification for amounts in excess of $750,000.

PHASE II PROPOSAL INVITATION

An MDA Program begins the process for a Phase II Invitation by making a recommendation (all MDA Topics are sponsored by MDA Programs). The MDA Program recommendation is based on several criteria. The Phase II Prototype/Demonstration (*What is being offered at the end of Phase II?),* Phase II Benefits/Capabilities (*Why it is important),* Phase II Program Benefit (*Why it is important to an MDA Program),* Phase II Partnership (*Who are the partners and what are their commitment? Funding? Facilities? Etc? This also can include Phase III partners*), and the Potential Phase II Cost. This is the basic business case for a Phase II invitation and requires communication between the MDA Program, the Phase I STTR Offeror, and the Phase I Technical Monitor.

The MDA Program recommends the Phase II Invitation to the MDA SBIR Steering Group. The MDA SBIR Steering Group will review the Phase II invitation recommendations and make a recommendation to the MDA SBIR Selection Official based on the above criteria and the availability of funding. The MDA Selection Official has the final authority. If approved by the MDA Selection Official then a Phase II Invitation is issued.

Phase II Proposal Submission

If you have been invited to submit a Phase II proposal, please see the MDA STTR website: http://www.winmda.com for further instructions.

All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the MDA specified deadline or may be declined.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. Your technical proposal, the DoD Proposal Cover Sheet, the DoD Company Commercialization Report (required even if your firm has no prior STTRs), and the Cost Proposal have been submitted electronically through the DoD submission site by 6 a.m. 21 March 2007.

____2. The Phase I proposed cost does not exceed $100,000

MDA STTR 07 Topic Index

MDA STTR 07 Topic Descriptions

MDA07-T001 TITLE: Laser Communication Systems for Geolocation and Attitude Determination

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: BMDS-MDA/SS, DV, BC, TC

OBJECTIVE: Develop innovative dual-use satellite attitude determination and geolocation capabilities utilizing laser communications links.

DESCRIPTION: Laser communication links between satellites provide pitch and yaw information on the relative attitude location between adjacent satellites. If range information is provided and three or more satellites are linked together in a ring type of formation, relative satellite attitude and geolocation can be determined. Furthermore, absolute knowledge can be determined if one of the satellite's orientation and location is known. Given this knowledge, users systems such as Low-Earth Orbit (LEO) satellites, or interceptor systems could use laser communication links as an attitude determination system, thus enabling lighter weight and less costly attitude determination hardware on those systems, or as a redundant system in case of primary system failure. Challenges include the transfer of attitude knowledge between same-satellite laser communication terminals, development of satellite ranging systems, and exploration of the complex algorithms required to extract roll attitude information. The object of this effort is to explore advanced hardware solutions coupled with innovative algorithms to provide complete attitude determination for a laser communication system of satellites.

PHASE I: Generate a conceptual intra-satellite tracking system with typical tracking errors (< ìrad) and ranging system with < 10m error. Create the algorithms needed to extract the satellite toll terms and verify performance.
Provide sub-scale demo, document results addressing future issues.

PHASE II: Fabricate a complete, operationally functional, satellite attitude determination device (based on selected Phase I technologies) capable of (laboratory based) military lasercom operation. Performance test this device under a full suite of environmental extremes, in addition to (among others)

PHASE III Dual Use Applications: Military application: The proposed technology will benefit all lasercomm programs for the military. Results apply to missions requiring high bandwidth communication and accurate pointing knowledge. Commercial application: Results apply to military and commercial missions requiring satellite formation flying or other missions requiring high bandwidth communication and accurate pointing knowledge.

REFERENCES:
1. Crassidis, John and Junkins, John, "Optimal Estimation of Dynamical Systems:, CRC Press, 2004.

2. Lambert, Stephen and Casey, William, "Laser Communications in Space", Artech House, May 1995.

3. Wertz, James, et al, "Spacecraft Attitude Determination and Control", Kluwer Academic Publishers, 1991.

KEYWORDS: laser communications, satellite, altitude determination, Unmanned Aerial Vehicles, pitch, yaw

MDA07-T002 TITLE: Small Scale Cryogenic Refrigeration Technology

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS-MDA/SS, DV, BC, TC

OBJECTIVE: Develop and model next generation meso and microscale cryogenic cooling technology to support small scale applications cooling for space sensors or exothermic kill vehicles between 10-100K.

DESCRIPTION: The ability to downscale current cryogenic refrigeration systems to meet smaller cooling load requirements in constrained volumes is predicated upon a comprehensive understanding of the scaling factors which limit the thermodynamic performance of such devices. As the spatial sizes of refrigerators are reduced, such factors as thermal conduction or viscous fluid drag in internal pipe flows come to predominate over usable compression and expansion phenomena which are associated with high refrigeration coefficients of performance. Designs for small scale refrigerators must therefore be based on the systemic limitations which are radically different than the limits on larger cryogenic refrigerators operating in space or in avionic systems today. Alternative fabrication methods for such systems would include use of micro electromechanical systems (MEMS) technology, LIGA (a German acronym meaning lithography, electroplating and molding), or miniaturized CinC and EDM. But these methods used must be within an overall design methodology which specifies the correct thermodynamic cycle working within correctly scaled thermal and fluid flow parameters. This topical request asks for either modeling of complete thermodynamic meso or microscale cycles or for modeling and fabrication of specific components to cycles, all of whose components (e.g. the compressor) might not be on a meso or microscale. For definitional purposes, "meso" will denote cooling loads less than 0.5 milliWatts of Exergetic Cooling (cooling load [W] x [abs. rejection temperature/abs. cooling temperature +1]), while "micro" will denote cooling less than one tenth of meso. Description of the normalized parametric constraints for these models and designs is required. Downscaling of current thermodynamic cooling cycles have potential for use in miniaturized expanders and as advanced heat exchangers (both recuperators and regenerators) that have applications in many cooling concepts including high temperature superconducting electronics, small array infrared sensors, or payload thermal management. Long life (> 5 years, 100% duty cycle) AC or DC flow compressors in the 1-10 W output power range are needed to enable the use of small cooling systems that utilize that compressor to cool multiple loads throughout any particular spacecraft. Dewars or thermal storage units enabling 10 minute mission durations for daughter satellites' focal plane array cooling at 60-80 K are also required. Offerors will be expected to obtain the necessary access to specific systems requirements as part of the phase I effort from the sponsoring MDA organization. These key technology developments will enable future cryogenic technologies and offer significant leaps in efficiency, performance, low temperature capability, and integration potential. Proposals do not have to attempt the creation of entire refrigeration systems, but rather should concentrate on the design and eventual demonstration of such systems' or their components' performance and reliability. The objective of the effort should be therefore to show how downscaling of current applications to the 0.01-0.5 milliWatts of exergetic cooling load range might be feasible in the objective temperature range, using either a single or multiply staged refrigeration design.

PHASE I: Phase I STTR efforts should concentrate on the development of the fundamental concepts. This could include system level modeling of a process or fundamental physical principles in a format that illustrates how this technology can be further developed and utilized in a cryocooler or as a refrigeration system. This effort should include plans to further develop and exploit this technology in Phase II. Offerors are strongly encouraged to work with relevant BMDS system and payload contractors to help ensure applicability of their efforts and beginning work towards technology transition.

PHASE II: Phase II STTR efforts should take the innovation of Phase I and design/develop/construct a breadboard device to demonstrate the component innovation, OR develop high fidelity system models of innovative refrigeration systems in the cooling range of interest. The components may not be optimized to flight levels, but should demonstrate the potential of the working prototype device to meet emerging operational specifications. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of a component innovation or full scale modeling program for the Phase III effort, to which end they should have working relationships with, and support from, relevant BMDS system and payload contractors.

PHASE III: Typical MDA military space applications relate to infrared sensing, electronics cooling, and superconductivity. Potential Phase III opportunities to transfer this technology to emerging MDA programs include the Advanced Space Based Infrared System and block upgrades to the Space Tracking and Surveillance System.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The applications of this technology could potentially be far reaching with large market potential due to the increased reliability and expected reduction in cost for cryogenic coolers. Applications of this technology include NASA, civil, and the commercial sector for space based and airborne uses such as missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. Other potential applications include CMOS (complimentary metal-oxide semiconductor) cooling for workstations and personal computers.

REFERENCES:
1. Davis, T. M., Tomlinson, B. J., and Ledbetter, J., "Military Space Cryogenic Cooling Requirements for the 21st Century", Cryocoolers 11, R. G. Ross, Jr., Ed., Plenum Press, New York (2001), pp. 1-10.

2. Shams, Q. A., Moniuszko, M., and Ingham, J. C., "Applying MEMS technology to field, flight & space deployable systems", ICIASF Record, International Congress on Instrumentation in Aerospace Simulation Facilities; ISSN: 0730-2010, Aug 2001; p.246-255.

3. Ruffin, P. B., and Burgett, S. J., "Recent progress in MEMS technology development for military applications", Proceedings of SPIE - The International Society for Optical Engineering; ISSN: 0277-786X, Mar 2001; v.4334, p.1-12.

4. Clifford, T., "MEMS: A view from aerospace", Circuits Assembly; ISSN: 1054-0407, October 2001; v.12, no.10, p.30-38.

5. Hanes, M., "Performance and Reliability Improvements in a Low-Cost Stirling Cycle Cryocooler", Cryocoolers 11, R. G. Ross, Jr., Ed., Plenum Press, New York (2001), pp. 87-94.

6. Razani, A. et al, "A Power Efficiency Diagram for Performance Evaluation of Cryocoolers", Adv. in Cryo. Eng., v. 49B, Amer. Inst. of Physics, Melville, NY; p. 1527-1535, 2004

7. G. E. Cruz, R. M. Franks, "MODIL Cryocooler Producibility Demonstration Project Results," Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.

8. Davis, T. M., Reilly, J., and Tomlinson, B. J., USAF "Air Force Research Laboratory Cryocooler Technology Development," Cryocoolers 10, R. G. Ross, Jr., Ed., Plenum Press, New York (1999), pp. 21- 32.

9. Pigg, G. and Wilderson, W. ,"INTEGRATION OF MINIATURIZATION TECHNOLOGIES IN A MISSILE SEEKER", AIAA–98-5288, A98-45913, 1998, p81-85

10. Moran, M. et al, "Microsystem Cooler Development", 2nd International Energy Conversion Engineering Conference, AIAA 2004-5611, 16 - 19 August 2004, p1-10

11. Ameel, T. A. et al, "Miniaturization Technologies for Advanced Energy Conversion and Transfer Systems", JOURNAL OF PROPULSION AND POWER, Vol. 16, No. 4, July–August 2000, p577-582

KEYWORDS: Micro Electrical Mechanical System, MEMS, LIGA, cryocooler, cryogenic

MDA07-T003 TITLE: Advanced Passive and Active Sensors for Discrimination Seekers

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: DV/DFT/DFG

OBJECTIVE: Research innovative concepts that will lead to the development of a new class of active electro-optical and/or passive infrared (IR) sensors for use in future ballistic missile discrimination seekers.

DESCRIPTION: Future ballistic missile defense may face complex countermeasures, such as multiple targets mixed with decoys, balloons and cool shrouded objects. Key functions of a missile defense interceptor are to detect, track and discriminate threat objects. These functions rely on the use of sensors that perform a variety of remote measurements that may include IR emission, shape, dynamics, range and range resolved shape. Both active and passive sensors, and their combination are critical for future discrimination seekers.

This topic solicits new ideas for passive and/or active sensors that will be able to detect, track, and discriminate complex targets at ranges beyond 1000 km. Passive IR sensor should have the capabilities of increased sensitivity, improved uniformity and operability, reduced readout noise, improved resolution, longer cutoff wavelengths (out to 14 microns), large array sizes (in excess of 256 x256), and high operating temperatures (above 100K). These performance parameters should exceed those of HgCdTe. Multi-color focal plane arrays (FPAs) designed to detect two to three wavebands simultaneously, for example MW/LW, LW/VLW or MW/LW/LW are of interest for measuring object temperatures. Active sensors such as laser radar, 2-D and 3-D ladar receivers and high-power, short wavelength lasers should have high efficiency, small volume and low cost. Performance parameters should exceed those of current ladar systems by a factor of at least 4. For example, high efficiency pulsed (10kHz) lasers less than 3 cubic inch, high power density (>100mJ/pulse), and thermal management technologies are needed. Large format ladar receiver and /or APD arrays operating at 1064 nm, associated ROIC with sub-nanosecond response time and in an excess of 40M carrier charge capacity unit cell are of interest. In summary, the innovative concepts, components and technologies to be developed under this topic include compact and light-weight laser radars (ladar), IR sensors, dual-mode active and passive sensor fusion, and system integration. On-FPA and near-FPA data processing and data rate reduction are very important in real time discrimination, and innovative concepts are also solicited.

PHASE I: Research, quantitatively analyze, and develop a conceptual design and assess the feasibility of an active, passive, or dual-mode sensor system or component. In case of a component it is desirable that a prototype be developed and demonstrated. For IR sensors, a single operating pixel or small size arrays will suffice.

PHASE II: Design, develop, and characterize a prototype of the active, passive, or dual-mode sensor system (or component) and demonstrate its functionality in a lab environment. For IR sensor, at lease 256x256 or larger array should be demonstrated. Investigate private sector applications along with military uses of key components developed in Phase II. Develop a commercial marketing plan.

PHASE III: Develop and execute a plan to manufacture the sensor system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The contractor will pursue commercialization of the developed concept/technology and EO/IR components developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses and homeland defense applications.

REFERENCES:
1. “The Infrared Handbook,” IRIA Series in Infrared and Electron- Optics, published by ERIM, 1993.

2. “MDA Infrared Sensor Technology Program and Applications,” M. Z. Tidrow, SPIE Proceedings, Vol. 5074 (2003), p39.

3. A. V. Jelalian, Laser Radar Systems, Artech House, Inc., 1992.

4. J. L. Miller, Principles of Infrared Technology, Chapman & Hall, 1994.

5. J. S. Acceta and D. L. Shumaker, The Infrared and Electro-Optical Systems Handbook,” SPIE Optical Engineering Press, Bellingham, Washington, 1993.

6. Schilling, B. W., et al., Multiple Return Laser Radar for 3-D Imaging Through Obscurations, Appl. Optics, 41, 2791 – 2799, 2002.

KEYWORDS: Discrimination, IR Detectors, Laser, Ladar, Active Sensors, Passive IR Sensor, Remote Sensing, Sensor Fusion, 2-D Detector Arrays, Focal Plane Arrays, IR FPA.

MDA07-T004 TITLE: Advanced Sensor Data Fusion

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: DV, BC, GM

OBJECTIVE: This topic seeks to apply innovative discrimination concepts to the fusion of sensor (feature) and contextual scenario information through the development of robust algorithms, software, and/or hardware necessary to collect, process, and fuse information from multiple sources (radars either at the same or different frequencies as well as EO/IR sensor assets). This topic further seeks to enhance the BMDS by forming a single integrated picture of the battlespace and assisting the warfighter in making decisions based on the evolving battlespace environment, with optimal discrimination and inference capabilities for threat identification being presented to the warfighter. Solutions must be capable of accurately and reliably supporting acquisition, track, discrimination, and engagement of threatening objects across a spectrum of threat classes and environments.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) performance is heavily dependent upon data from dispersed and disparate radars and other types of sensors. Timely and accurate fusion of data collected from a variety of radars and/or other sensors that acquire information from multiple perspectives and/or different frequencies can provide for a more accurate picture of the adversary threat cloud than any single radar, group of radars and/or EO/IR sensors operating independently. The goal of the data fusion process is to operate on a combination of sensor measurements, features, track states, and object type and identification likelihoods to produce a highly accurate integrated picture of the battlespace. Innovative techniques applied to the BMDS realm which are grounded in advanced mathematical decision theory and/or probabilistic inferencing algorithms as well as software, and/or hardware that enable this synergistic fusion and interpretation of data from disparate BMDS radars and/or other sensors should enhance system acquisition, tracking and discrimination of threat objects in a cluttered environment and provide enhanced battlespace awareness. Fusion of data at several levels may be required. Technical issues that must be addressed include: sufficiently accounting for uncertainty in both threat genealogy and sensor feature measurements, over-reliance on apriori information, spatial and temporal registration of radars, data throughput within and between sensor platforms, processing speed and capacity, data latency and gap handling, target feature exploitation, and sensor calibration. Of additional interest are methods for fusing multi-sensor data for 3-dimensional imaging for discrimination purposes. This includes multiple radar data, as well as on-board IR sensor data and active LADAR device data. Further fusion of data with other radar or a-priori data would also be useful.

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced sensor data fusion concepts using simulated sensor data.

PHASE II: Update/develop technology (algorithms, software, hardware, or a combination thereof) based on Phase I results and demonstrate technology in a realistic environment using data from multiple Radar assets sources. Demonstrate ability of technology to work in real-time in a high clutter environment.

PHASE III: Integrate technology into BMDS system and demonstrate the total capability of the updated system. Partnership with traditional DOD prime- contractors will be pursued as government applications of this technology will produce near term benefits from a successful program.

REFERENCES:
1. R. Duda, P. Hart, and D. Stork, “Pattern Classification”, 2nd Ed., Wiley Interscience, November, 2000

2. Jenson, Finn V. Bayesian Networks and Decision Graphs. New York: Springer, 2001

3. Gilks, W.R., Richardson, S. and Speigelhalter, D.J. Markov Chain Monte Carlo In Practive. Boca Raton: Chapman & Hall, 1996

4. Neapolitan, Richard E. Learning Bayesian Networks. Upper Saddle River: Prentice Hall, 2004

5. Martinez, David, et.al., “Wideband Networked Sensors”, MIT Lincoln Labs, http://www.fas.org/spp/military/program/track/martinez.pdf, October 2000

6. D. Hall and James Llinas, “An Introduction to Multisensor Data Fusion,” Proceedings of the IEEE, 85 (No. 1) 1997

7. D.C. Cowley and B. Shafai, “Registration in Multi-Sensor Data Fusion and Tracking,” Proceedings of the American Control Conference, June 1993

8. Y. Bar-Shalom and W.D. Blair, Editors, Multi-Target/Multi-Sensor Tracking: Applications and Advances, Vol. III, Artech House, Norwood, MA, 2000

9. T. Sakamoto and T. Sato, “A fast Algorithm of 3-dimensional Imaging for Pulsed Radar Systems,” Proceedings IEEE 2004 Antennas and Propagation Society Symposium, Vol. 2, 20-25 June 2004

10. W. Streilein, et al. “Fused Multi-Sensor Mining for Feature Foundation Data,” Proceeding of Third International Conference of Information Fusion, Vol. 1, 10-13, July 2000

KEYWORDS: Inferencing Algorithms, Decision Theory, Sensor Fusion; Data Fusion; Sensor Integration; Signal Processing; Algorithm; Multi-Sensor, 3-D Imaging

MDA07-T005 TITLE: <u>Sensor Registration / Sensor Management</u>

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: DV, GC

OBJECTIVE: Develop advanced, innovative, robust, real-time techniques (algorithms and software) for the real-time tasking of diverse and distributed sensor resources to optimize the collection of threat data in a multi-target environment to meet competing requirements for accurate tracking and discrimination in order to support weapon assignment management.

DESCRIPTION: The Ballistic Missile Defense System (BMDS) employs multiple sensors, (optical and radar) in the detection, tracking, and identification of ballistic missiles and their constituent pieces. These sensors are geographically dispersed and have differing sensor data capability. These differing sensor data capabilities must be fused together to provide a single integrated operational picture for the warfighter. As the BMDS evolves to incorporate new and enhanced sensors and weapon systems to contend with the increasingly complex ballistic missile threats, the sensor registration capability and control / tasking of these sensor systems will become increasingly complex and difficult, requiring the operators to be supported by innovative sensor registration and sensor planning / scheduling algorithms /tools to provide a single integrated picture of the battle space. The available range of spatially separated EO/IR and radar sensors, each with its own temporally and geometrically constrained view of the battle space, will have increasing demands placed upon them as the need for collection of target tracking and discrimination information expands to cope with countermeasures.

Proposals for the development of innovative sensor registration / management techniques / algorithms for sensor data fusing and scheduling / management of sensors is invited. Sensor registration techniques / algorithms should clearly identify performance improvement for the fused data. Sensor management techniques may be based on dynamic programming or approximations thereto, stochastic programming or otherwise. The proposed sensor management scheme should allow for the need for dynamic reallocation of sensors in response to changing threat priorities and complexity, and arising from changes to sensor availability

In proposing schemes, recognition should be made of the following features:
1. Some sensor tasks will benefit from simultaneous observations from different platforms.
2. Depending on the objective, required observations may differ in character from short single looks through frequent revisits to sustained periods of continuous observation.

3. For some sensors, the slew and reacquisition time can be significant and constrain the ability to observe objects with large angular separation.
4. Priorities for sensor tasking must reflect the need to provide fire control solutions for weapon systems appropriate to each layer in the BMDS architecture.
5. The fidelity of track and discrimination information required will vary with time to match key decision points in an engagement.
6. Sensor resources will be required post interceptor launch to support tracking, in flight target update of threat state vectors and discrimination state and provide kill assessment.

Proposed schemes should clearly identify how the performance improvement resulting from extending at any time the algorithm's planning horizon "far sightedness" is achieved at the expense of increased computai9onal complexity to allow trade-offs of performance against processing load.

PHASE I: Develop a mathematical basis for the proposed approach, augmented as appropriate by coding or analysis sufficient to demonstrate it's computational and performance abilities to handle the features 1 – 6 listed above.

PHASE II: Develop / update the technology based on Phase I and provide a demonstration of the technology in a realistic simulation environment, to include using realistic scenarios.

PHASE III: Integrate the algorithm(s) into the MDA Command & Control, Battle Management & Communications (C2BMC) architecture. Partnership with traditional BMDS prime contractors will be pursued as government applications of this technology will produce near term benefits for a successful program.

REFERENCES:
1. Kreucher et al. – Efficient Method of non-Myopic Sensor Management for Multi- target tracking. 43rd IEEE Conference on Decision and Control. December 2004.

2. D.P. Bertsekas. – Nonlinear Programming Second Edition. Athena Scientific. 1999.

3. D.A. Castanon. – Approximate Dynamic Programming for Sensor Management. Proceedings of the 36th IEEE Conference on Decision and Control 1997.

4. Bar-Shalom, Y. and Blair, W.D., Editors, Multi-target / Multi-sensor Tracking: Applications and Advances, Vol III, Artech House, Norwood, MA, 2000.

KEYWORDS: sensor registration, sensor management, resource allocation

MDA07-T006 TITLE: Freeform Optical Systems for Defense System Optics

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: MDA/DEP

OBJECTIVE: Develop more compact, lightweight and lower cost optical telescopes for space and missile interceptor sensors. Freeform shapes, such as biconics or Zernike surfaces, provide the designer with the flexibility to reduce aberrations and improve the optical performance or to reduce the system size with the same performance. Research and development in the areas of design, fabrication, measurement and assembly are needed. The applicable systems include high precision, lightweight optics (telescopes and gimbals) using both active and passive detection in the visible through IR wavelengths.

DESCRIPTION: The benefits of freeform surface shapes have long been known by optical designers [1,2]. Freeform surfaces provide additional degrees of freedom that can be used to lower wavefront error and distortion when compared to a system with the same number of rotationally symmetric surfaces. The ability to specify the surface shape at each field point is the key to this advantage and it is lost when the constraint of a symmetric surface is imposed. For example, the oblique ray incidence angles in an unobscured mirror system with tilted and decentered components introduce aberrations that can be corrected by specifying different local base radii of curvature in the orthogonal directions at each point on the surface.

Unfortunately, designers of cost-effective imaging systems avoid freeform surfaces due to the challenges of design, fabrication, metrology and assembly of such surfaces. To adequately address these challenges, new research and development must be performed in the following areas:
• Design software that is manufacturing aware and provides the designer with feedback on the cost and effort to fabricate the optical surface.
• Fabrication systems that can take the optical design specification and create commands to generate surfaces that meet surface form and finish requirements.
• Metrology methods that can measure the optical surfaces shape without the slope limitations of interferometry with computer generated holograms.
• Assembly strategies that locate and support the optical surface in a optical frame without distorting the optical surface or requiring post-assembly adjustment Proposals for this topic could include the development of methods that can address these infrastructure issues and hasten to the introduction of freeform optical systems.

PHASE I: Develop techniques that can be applied to design, fabricate, measure and assembly freeform optical systems. Perform a proof-of-concept demonstration on a scaled sample. Develop path to scale up the process to be used on seeker missile optical systems.

PHASE II: Continue development of process identified in Phase I with a goal of scaling the process to be implemented on large, lightweight optics.

PHASE III: Continue development of process identified in Phase I and II with a goal of making the process robust to be used on other commercial applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Precision optics throughout the industry e.g., photolithography, defense, space, etc., are being assigned more stringent specifications for space and performance. Fabrication and test methods must be developed and implemented to address this growing demand.

REFERENCES:
1. Plummer, W.T., “Freeform Optical Components in some Early Commercial Products”, Proceedings of the ASPE Topical Meeting on Freeform Optics, Vol 31, 2004, pg 68.

2. Rodgers, M.J. and Thompson, K.P., “Benefits of Freeform Mirror Surfaces in Optical Design”, P73.

KEYWORDS: freeform optics, design, fabrication, metrology, assembly

MDA07-T007 TITLE: Rechargeable Lithium Battery Operating Life Model

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/DEP

OBJECTIVE: Develop high fidelity, mechanism and empirically-based software models to describe the long term behavior of rechargeable lithium battery charge/discharge cycling in aerospace applications.

DESCRIPTION: The lithium ion cell chemistry promises approximately a 2x performance enhancement over the current generation of conventional space qualified batteries (NiCd, NiH_2) in terms of energy density (Whr/kg) and volume density (Whr/kg). Incorporating lithium ion batteries will have significant impact on future application performance in terms of power available and the saving of weight, which greatly affect launch and overall program costs. To date, lithium ion batteries have had limited use or even testing in space but are now being base-lined for a number of satellite programs -- mostly in the civilian commercial sector. Lithium ion has not replaced conventional batteries in US systems to any significant degree, although a number of ground test programs are underway to explore rechargeable lithium battery use for domestic commercial and military programs.

There are some major concerns with adapting rechargeable lithium batteries for space applications, including reliability and cycle life for long-term missions (e.g. 10 years) in low earth orbits (LEO). It is difficult, if not impossible, to conduct and conclude real-time life testing of lithium ion batteries since this would delay (by 5 or 10 years) making decisions regarding technology insertion. A way to shorten this decision time is to use high fidelity battery models to evaluate the suitability of a lithium battery design in a reasonable time frame.

Cycle and calendar life models are important tools that describe expected performance of rechargeable batteries during the many charge and discharge cycles of their operating life. These models allow prediction of useable lifetimes, capacity fade, optimizing designs and troubleshooting battery problems. Because rechargeable lithium batteries (i.e. series and parallel strings of Li ion, Li polymer ion or Li polymer) are relatively new in aerospace applications, and advanced life models are needed to more accurately predict battery behavior under various conditions.

The rationale for pursuing advanced cycle life models is to better accommodate the need to predict and simulate the next generation of aerospace batteries. Because of variation between types of batteries and the specific needs of aerospace applications, “generic” and other simplified models are unusable for this purpose. Some modeling has taken place previously at lithium ion battery vendors and other facilities, but these models do not adequately address all the significant real-world factors that affect battery operation.

Building a complex, all-encompassing model will require further refinements to existing efforts and new development describing interaction effects to serve the purposes of this announcement. It is necessary to develop specific cycle life models with sufficient fidelity to make reliable predictions. The success of, and fidelity of, these models will allow accelerated testing of different lithium ion chemistries and provide evidence for decision makers to propose adoption of lithium ion cells for specific programs. An additional result of the advanced model is to guide power subsystem designers with operational characteristics (such as temperature of operation and depth of discharge) of batteries for particular programs.

PHASE I: For phase I, a proof of concept model demonstration per the described intentions should be attempted which is capable of approximating battery behavior during cycle life by showing how the battery cells, of various capacities in various series and parallel string configurations, react to an imposed charge/discharge cycle. A suitably successful proof-of-concept demonstration leads to the possibility of a phase II effort.

PHASE II: For phase II, a higher fidelity model will be demonstrated for sets of cell configurations and variable charge/discharge profiles over extended periods of time. Variables such as non-uniform cell temperatures, cell unbalance and other identified parameters and mechanisms must be suitably
accommodated. A suitable user-interface for the software model will also be demonstrated. Successful model validations against provided data from existing hardware demonstrators leads to the possibility of a phase III effort.

PHASE III: Phase III encompasses final optimization of the software model and user interface for specific aerospace applications. As well, the model will be capable of additional “real world” conditions to provide high fidelity simulation of the lithium battery and system electronics.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Lithium rechargeable batteries are quickly becoming the battery of choice for many commercial applications. A model that adequately describes the underlying mechanisms of long-term battery operation, degradation and failure would be useful to other aerospace and some commercial battery users. Such a model would likely be adaptable (given security, proprietary information and system specific behavior concerns that would have to be addressed) for common rechargeable lithium cell types as used in consumer applications.

REFERENCES:
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3. Jungst, Rudolph G.; Doughty, Daniel H.; Liaw, Bor Yann; Nagasubramanian, Ganesan; Case, Herbert L.; Thomas, Edward V. Lithium-ion cell accelerated aging and life prediction. Proceedings of the Power Sources Conference (2002), 40th.

4. Inoue, Takefumi; Sasaki, Takeshi; Imamura, Nobutaka; Yoshida, Hiroaki; Mizutani, Minoru; Goto, Masayoshi. Calendar and cycle life prediction of 100 Ah lithium-ion cells for space applications. NASA Conference Publication (2002), 2002-211466 (NASA Aerospace Battery Workshop, 2001), 452-459.

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KEYWORDS: Lithium, Battery, Rechargeable, Model, Software, Cycle-life

MDA07-T008 TITLE: Hypergolic Safety Modeling & Simulation

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: MDA/QS, OSD AT&L

OBJECTIVE: Develop and validate modeling and simulation (M&S) toolset for safety assurance of hypergolic fuel use in missile defense applications.

DESCRIPTION: Hypergolic propulsion provides significantly greater specific impulse than solid propulsion and enables faster, broader, more robust missile defense coverage. However, safety assurance for design and employment of missile defense systems using hypergolic fuels is limited by M&S capability shortfalls. There is some technology for monitoring sensors and mitigations of undesired effects at the propulsion subsystem, missile round and magazine levels. However, safety can not be quantified for the entire system, including exterior and interior spaces of the launch platform. M&S capability is also needed for the design of robust monitoring sensors and mitigations, and management of undesired hypergolic fuel or munitions events. This topic seeks M&S approaches enabling system design and employment of missile defense systems using hypergolic fuel. A validated M&S capability to quantify hypergolic fuel and munitions safety, design monitoring/mitigation subsystems and aid consequence management planning is the ultimate goal of this topic.

PHASE I: Propose and assess a M&S approach to system of systems safety quantification for hypergolic fuel use in missile defense applications. Define testing necessary for validation. Prepare M&S development and validation plan.

PHASE II: Develop models and perform simulations of the system of systems(propulsion/missile, AUR/launcher/platform). Define details of the validation plan including test bed. Collaborate with the proposed tester on test plan and execution. Analyze test data, compare simulation versus test results, and update simulation as necessary.

PHASE III: Transition M&S capability to industry for incorporation in a missile defense system development using hypergolic fuel.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Military equipments including missile systems using hypergolic fuels will be the primary beneficiary. The propulsion industry will benefit from improved M&S and knowledge on safer storage, handling, transportation and use of hypergolic fuels.

REFERENCES:

1. Mil-Std-1522A: Standard General Requirements for Safe and Operation of Pressurized Missile and Space Systems.

KEYWORDS: Hypergolic, Munitions, Design, Modeling and Simulation

MDA07-T009 TITLE: <u>Expedited Transition of Propulsion Modeling & Simulation Capability</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Weapons

ACQUISITION PROGRAM: MDA/QS, OSD AT&L

OBJECTIVE: Expedite industry transition of a validated safety and IM related modeling & simulation (M&S) capability for propulsion design and integration.

DESCRIPTION: The topic focus is large rocket motor propulsion systems (> 20 inch diameter) as required to meet range and burnout velocity requirements for missile defense. Industry currently lacks the M&S tools necessary to quantify the trade space for performance vs. safety. Full-scale testing of large propulsion systems for Insensitive Munition (IM) and other safety hazards is too costly. More importantly, it is not practical due to lack of sufficiently large instrumented test facilities. The traditional alternative has been to apply for safety and/or IM waivers (forcing acceptance of unquantified risk). An experimentally validated M&S capability is urgently needed to broaden the design space and enable risk quantification. Currently DoD/OUSD (AT&L)undertook a Weapons and Munitions M&S initiative as a portion of their Systems Acquisition Portfolio for Land Warfare & Munitions (LW&M), which will result in an initial IM & safety hazard M&S capability during FY08-10. Additional support is needed to verify models, create user interfaces, and further develop the models for easy integration into industry. This proposal asks that the small business leverage, support or base their advancements off of the current work and models that have been produced by the DoD/OUS(AT&L) M&S program. The goal of the project is to produce an M&S program/utility that is easy to use and easily integrated into current industry programs and technology bases. The primary focus will be the development and growth of engineering models and codes to address primarily impact hazards from fragments and bullets. The secondary focus in later years will be on thermal hazards such as fast and slow heating. Assist the LW&M management team, via appropriate venues, to expedite and assure efficient, effective integration of the models and codes, and transition these M&S tools to industry and government users.

PHASE I: Develop testing protocols that test the validity of the models and will produce data required to fill voids in the models. Develop a user interfaceor data organization structure which can easily be integrated into current industry models.

PHASE II: Based on work completed by the DoD/DoE Joint Munitions programs refine the test protocols and industry interfaces.

PHASE III: Transition improved M&S capability to industry for incorporation in a missile defense system development requiring large IM propulsion systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Military equipments including missile systems using large IM propulsion systems will be the primary beneficiary. The propulsion industry will benefit from improved M&S capability as an enabler to improve the knowledge base for safer storage, handling, transportation and use of large propulsion systems.

REFERENCES:

1. “Experimental Support of a Slow Cook Off Model Validation Effort” by Alice Atwood, November 2004

2. NATO’s Munitions Safety and Information Analysis Center (MSIAC, formerly NIMIC)

3. “US DOD IM Program” by Anthony J. Melita (http://ww.dtic.mil/ndia 2003gun/mel.pdf)

KEYWORDS: Large Propulsion, Propellants, Insensitive Munitions, Safety, Design Capability, Modeling & Simulation

MDA07-T010 TITLE: Radiation Hardened Interceptor Communications

TECHNOLOGY AREAS: Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: GMD / MKV/ KI / DV

OBJECTIVE: Develop innovative concepts to enhance the radiation hardness of high speed, in-flight communications between the Ballistic Missile Defense System (BMDS) Fire Control and Interceptor/Kill Vehicles. Increase probability of message delivery by In-Flight Interceptor Communication System (IFICS) under adverse conditions, especially under high altitude nuclear explosions(HANEs). Provide analysis of proposed high-speed communications solutions within the framework of the Missile Defense Agency (MDA) layered architecture and prototype hardware that will demonstrate the utility of the proposed solution.

DESCRIPTION: MDA is seeking innovative, high speed/ wide band communications methodologies for current systems as well as future Interceptor/Kill Vehicle systems. In any future MDA communication architecture, IFICS solutions will have to provide robust communications links with the ability to handle fading channels due to jamming and Nuclear Weapons Effects, including high altitude nuclear explosions. In addition, there is a finite set of available RF spectrum options that can be assigned and authorized to any particular communications solution. Specific issues that the successful bidder should consider include:

1. Selection of the RF spectrum and allocation constraints.
2. Platform weight, size, and power constraints (especially on flight vehicles).
3. Link Attributes (i.e., data rate, bandwidth, range, latency, error rates, ...).
4. Channel waveform design, simulation and insertion (such as the use of Turbo Codes, different IF or RF Frequencies via upgradeable modules, support of transceiver-to-simulator RF interfaces between 70 MHz and 44 GHz, channel descriptions in Time Domain or Frequency Domain,...).
5. High altitude nuclear effects.
6. Jam and Intelligence gathering resistance.
7. Interference avoidance with and from the existing communications systems.
8. Transmission during ground and range testing as well as during wartime operations.
9. Beyond Line Of Sight (BLOS) connectivity.
10. New technology insertion alternatives and schedules.
11. Cost trades of proposed communications solutions.

Attention should be paid to the investigation of new technologies for the MDA Radiation Hardened Interceptor Communications Systems. Of special interest to MDA is the insertion of diamond and carbon technologies. Any proposed communications schemes must be scaleable as Missile Defense architectures grow in both geographic coverage (locations & platforms) and in hardware(number and type of interceptors or kill vehicles). Implications of frequencies and waveforms recommended such as interference potential, spectrum allocations, modulation coding, etc. must be considered for wartime and peacetime operations (e.g. integration, routine tests).

PHASE I: Contractors shall propose and analyze candidate communications solutions for providing high speed/ wide band connectivity to missiles and/or kill vehicles within the evolving MDA architecture. The contractor shall identify the strengths/weaknesses associated with different solutions/ concepts. The output shall be a set of communications system and hardware trades, which substantiate the proposed solution(s) and provides quantifiable metrics for comparison. Issues associated with the high altitude nuclear explosions and insertion of new technologies shall be highlighted.

PHASE II: The contractor shall select the optimal candidate radiation hardened communications solution proposed in Phase I and perform a detailed design of the system. Specific hardware components will be identified and new designed initiated if necessary. New technologies will be developed and demonstrated for hardness, reliability and performance. Contractor shall begin coordination with MDA contractors to ensure products will be relevant to ongoing and planned projects.

PHASE III: The contractor shall work with MDA industrial partner(s) to maximize the transfer of this development to missile defense and is expected to identify a tractable Phase III project as a by-product of this overall program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Other efforts within the DoD are focused on two-way data links to weapons systems and this technology will, most likely,be transferred to those programs. The number of weapons that could ultimately use this technology would be substantial. Commercial applications would be in the cell-phone industry, airline communications, and over-the-air communications.

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1. Digital Communications in Fading Channels: Modulation and Coding, R. L. Bogusch. Mission Research Corp., Report for Air Force Weapons Lab, Kirtland Air Force Base, NM, 1989.

2. DARPA Tactical Targeting and Network Technology (TTNT) program http://dtsn.darpa.mil/ixo/programdetail.asp?progid=9.

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6. MIL-STD-461, "Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference", military standard, procedure CE106.

7. DD 1494, "Application For Equipment Frequency Allocation", Department of Defense Form.

8. "Hearing of the Military Research and Development Subcommittee of the House National Security Committee on Electromagnetic Pulse Threats," Federal News Service, Federal Information Systems Corporation, July 16, 1997; and Office of Technology Assessment, "The Effects of Nuclear War," May 1979.

9. Professor David Jenn, “ATMOSPHERIC NUCLEAR EFFECTS”, Naval Postgraduate School, Monterey, California.

KEYWORDS: communications architecture, jamming, high altitude nuclear explosions, advanced carbon technologies, channel trades, RF data link, spectrum management, fading channel, spectrum allocation.

MDA07-T011 TITLE: Low Cost Planar Antennas for Phased Array Radars

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Space Platforms

ACQUISITION PROGRAM: MDA/DV

OBJECTIVE: Design, develop, integrate and demonstrate innovative low-cost planar antennas for use in large active array radars.

DESCRIPTION: Low power density X-band phased array radars have strong potential for enabling more affordable radars capable of robust mission and basing support. A critical component currently inhibiting the realization of this concept is the array radiators. Technology advancements are required in low cost, high performance radiator and array designs, and their associated electronics. Of specific interest are concepts and materials supporting highly manufacturable planar antenna concepts. Successful efforts under this topic will quantify the performance achieved in terms of bandwidth (operational bandwidth across entire X-band range, instantaneous bandwidth 2x state-of-the-art), axial ratio, polarization, antenna performance capability, ease of manufacture, and antenna functionality. Proposals must demonstrate knowledge of the unique requirements and constraints of active phased array radar systems, and demonstrate the potential for cost effective, producible implementation. The goal is a 50% reduction in life cycle costs for radar antennas and their associated electronics.

Designs and developments leading to reductions in power density and enabling full field of view operation (360 degree hemispherical coverage), elimination of grating lobes and scan blindness, and increases in bandwidth and efficiencies, and reduction in cost are encouraged. Light-weight, low-cost antennas employing advanced materials are also of primary interest. Using state-of-the-art radiator materials devices offering equal performance and footprint compared to conventional radiator designs, demonstrate performance of radiators in an active array concept. This can be demonstrated through the integration of multiple radiators and printed circuit technology into mutual coupling arrays, and demonstration of subsystem/system performance of the arrays in a test range.

The goals of this research are to provide more compact, reliable, efficient, powerful, manufacturable, low cost low power density apertures that will support affordable full field-of-view X-band radars while decreasing the hardware, logistics, and associated operating costs required by current systems.

PHASE I: Demonstrate the likelihood that a new and innovative radiator material or technique such as fractional arrays can be integrated into a circuit board design, integrated into an array panel, and multiple panels can function and operate as a radar antenna.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability. Integrate multiple radiators into an array panel and demonstrate operation of the panel in a test environment. Show transition of multiple panels into a radar antenna.

PHASE III: Develop pre-production and production radiators and sub-systems for integration into advanced radar systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These technologies are applicable in many RF applications such as the telecommunications industry, commercial airport radar systems, and electronics industry.

REFERENCES:
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KEYWORDS: radar; radiator; RF; antenna array; fragmented aperture